

Fishery Data Series No. 97-17

Abundance and Composition of the Northern Pike Population in Minto Lakes, 1996

by

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September 1997

Alaska Department of Fish and Game

Division of Sport Fish



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Weights and measures (metric)		General		Mathematics, statistics, fisheries	
centimeter	cm	All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.	alternate hypothesis	H_A
deciliter	dL			base of natural logarithm	e
gram	g	All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.	catch per unit effort	CPUE
hectare	ha	and	&	coefficient of variation	CV
kilogram	kg	at	@	common test statistics	F, t, χ^2 , etc.
kilometer	km	Compass directions:		confidence interval	C.I.
liter	L			correlation coefficient	R (multiple)
meter	m	east	E	correlation coefficient	r (simple)
metric ton	mt	north	N	covariance	cov
milliliter	ml	south	S	degree (angular or temperature)	°
millimeter	mm	west	W	degrees of freedom	df
		Copyright	©	divided by	÷ or / (in equations)
		Corporate suffixes:			
		Company	Co.	equals	=
		Corporation	Corp.	expected value	E
		Incorporated	Inc.	fork length	FL
		Limited	Ltd.	greater than	>
		et alii (and other people)	et al.	greater than or equal to	≥
		et cetera (and so forth)	etc.	harvest per unit effort	HPUE
		exempli gratia (for example)	e.g.,	less than	<
		id est (that is)	i.e.,	less than or equal to	≤
		latitude or longitude	lat. or long.	logarithm (natural)	ln
		monetary symbols (U.S.)	\$, ¢	logarithm (base 10)	log
		months (tables and figures): first three letters	Jan,...,Dec	logarithm (specify base)	log ₂ , etc.
		number (before a number)	# (e.g., #10)	mid-eye-to-fork	MEF
		pounds (after a number)	# (e.g., 10#)	minute (angular)	'
		registered trademark	®	multiplied by	x
		trademark	™	not significant	NS
		United States (adjective)	U.S.	null hypothesis	H_0
		United States of America (noun)	USA	percent	%
		U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)	probability	P
				probability of a type I error (rejection of the null hypothesis when true)	α
				probability of a type II error (acceptance of the null hypothesis when false)	β
				second (angular)	"
				standard deviation	SD
				standard error	SE
				standard length	SL
				total length	TL
				variance	Var
Weights and measures (English)					
cubic feet per second	ft ³ /s				
foot	ft				
gallon	gal				
inch	in				
mile	mi				
ounce	oz				
pound	lb				
quart	qt				
yard	yd				
Spell out acre and ton.					
Time and temperature					
day	d				
degrees Celsius	°C				
degrees Fahrenheit	°F				
hour (spell out for 24-hour clock)	h				
minute	min				
second	s				
Spell out year, month, and week.					
Physics and chemistry					
all atomic symbols					
alternating current	AC				
ampere	A				
calorie	cal				
direct current	DC				
hertz	Hz				
horsepower	hp				
hydrogen ion activity	pH				
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

FISHERY DATA SERIES NO. 97-17

**ABUNDANCE AND COMPOSITION OF THE NORTHERN PIKE
POPULATION IN MINTO LAKES, 1996**

by

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September 1997

Development and publication of this manuscript were partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-12, Job No. R-3-4(c).

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This document should be cited as:

Roach, S. M. 1997. Abundance and composition of the northern pike population in Minto Lakes, 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-17, Anchorage.

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ABSTRACT

Abundance and composition of the northern pike *Esox lucius* population within the Minto Lakes Study Area in middle to late June 1996 was described using mark-recapture techniques. In 1996, estimated abundance of northern pike ≥ 400 mm FL was 23,850 fish (SE = 7,799 fish; 95% profile likelihood bounds were 14,117 and 63,507 fish). Fork lengths measured from 899 northern pike ≥ 400 mm FL from Minto Lakes ranged from 400 mm to 1,002 mm (mean = 596 mm; SE = 3 mm). Of 838 Minto Lakes northern pike ≥ 400 mm FL, 51% (SE = 2%) were age-5. The mean error in assigning the proper incremental ages from the scales of 18 northern pike recaptured from previous years was -0.72 years ($Z = 0.77$; $P = 0.44$). The estimated average percent error of the scale reader in reproducing the same age twice from a Minto Lakes northern pike scale in 1996 was 2.8%. In comparison to four previous estimates of abundance for Minto Lakes northern pike ≥ 525 mm FL from 1987 to 1991 that ranged from 11,257 (SE = 3,075) to 27,418 (SE = 6,800) northern pike, abundance of Minto Lakes northern pike ≥ 525 mm FL in 1996 was 20,695 (SE = 6,765).

Key Words: Northern pike, *Esox lucius*, population abundance, age composition, length composition, Minto Flats, Minto Lakes, mark-recapture.

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) initiated northern pike *Esox lucius* studies in the Arctic-Yukon-Kuskokwim Region of Alaska (AYK) to insure that annual harvests do not exceed surplus production of northern pike. Objectives designed to meet this goal have included estimates of abundance, length composition, age composition, mortality rates, recruitment, and movements of northern pike within selected lakes and wetland complexes in AYK. Prior to 1996, ADF&G conducted mark-recapture experiments in Minto Flats from 1987 through 1991 (Burkholder 1989, 1990, 1991; Hansen and Burkholder 1992). Generally, sampling events were conducted during spring or fall movements of northern pike and concentrated on one area of Minto Flats. The designs of these between-season and between-year mark-recapture experiments were contingent upon either, 1) marked fish being distributed throughout Minto Flats during the recapture event to estimate abundance of northern pike for the entire Minto Flats; or, 2) the fidelity of northern pike to the area of Minto Lakes from one season to the next or one year to the next to estimate abundance for a subpopulation of northern pike. These studies were abandoned after 1991 because investigations indicated that neither of these assumptions were valid for between-year or between-season experiments.

Frost and Kipling (1967) presented evidence from tagging experiments in Windermere Lake that northern pike demonstrated fidelity to specific spawning areas from one year to the next. However, Franklin and Smith (1963) observed that northern pike in Minnesota did not demonstrate fidelity to a particular spawning ground. Evidence from Minto Flats indicated that some northern pike returned to the same spawning area between years (Burkholder 1989) but did not demonstrate complete fidelity to one area between years. Given that fish present during the marking events moved out of, and new fish moved into, the sampling area between sampling events, between-year and between-season estimates of abundance from Minto Flats are biased. Estimates of abundance are biased high when applied to just the sampling area and biased low when applied to all of Minto Flats (Seber 1982). It was hypothesized that a within-season estimate of abundance for the Minto Lakes area of Minto Flats may be more practical and less susceptible to bias from site infidelity. To achieve an unbiased estimate of abundance, an in season single-mark release experiment requires a closed population, or at the least, movement in only one direction, either into the sampling area or out of the sampling area but not both.

Summer sampling might also reduce size- and sex-selective sampling. Casselman (1975) reported that male and female northern pike exhibited biannual peaks of availability to the gear, resulting in inherent sampling error. Males were relatively more abundant in spring and fall. He suggested that composition bias was related to differential timing of movements to spawning and overwintering areas by sex and not necessarily related to locality or method of capture. Neumann and Willis (1995) reported that males moved into and out of spawning areas faster than females and entered spawning areas first. A higher percentage of males were captured during the spawning period suggesting greater activity of males during this time. These studies suggest that northern pike are more likely to have the same probability of capture by length and sex after spawning and before fall movements.

1996 RESEARCH OBJECTIVES

Current status of northern pike was evaluated with a two-event mark-recapture experiment on fish in the Minto Lakes area of Minto Flats in 1996. The research objectives were to:

- 1) estimate the population abundance of northern pike ≥ 300 mm FL in Minto Lakes such that the estimate is within 25% of the actual value 95% of the time; and,
- 2) estimate the age and length compositions of the northern pike population ≥ 300 mm FL in Minto Lakes such that the estimates of proportions are within 5 percentage points of the actual value 95% of the time.

DESCRIPTION OF MINTO FLATS STUDY AREA

Minto Flats is located approximately 50 km west of Fairbanks, Alaska within the Tanana River drainage (Figure 1). It is a 200,000 ha area of marsh and lakes interconnected by numerous sloughs and five rivers: the Chatanika, Goldstream, Tatalina, Tolovana, and Tanana (Figure 2). Except for the Tanana River, these rivers are slow flowing and meandering. The Tanana River is a large glacial river that delineates the southern boarder of the flats and is the primary water source for Swanneck and Grassy Sloughs. The lakes of Minto Flats are generally shallow and contain large areas of dense aquatic vegetation. Summer habitat for northern pike in Minto Flats covers approximately 6,000 ha (Holmes and Pearse 1987). Investigators, however, identified the Minto Lakes area¹ of Minto Flats as a primary northern pike spawning and summer feeding area. In recent years, the majority of Minto Flats northern pike sport fishing effort has occurred in the Minto Lakes area. ADF&G concentrated on this area for mark-recapture experiments

¹ This area is also referred to in some reports as Minto Flats Area I, which includes the lakes, channels, and sloughs that empty into the Chatanika River by way of Goldstream Creek (see Figure 2).

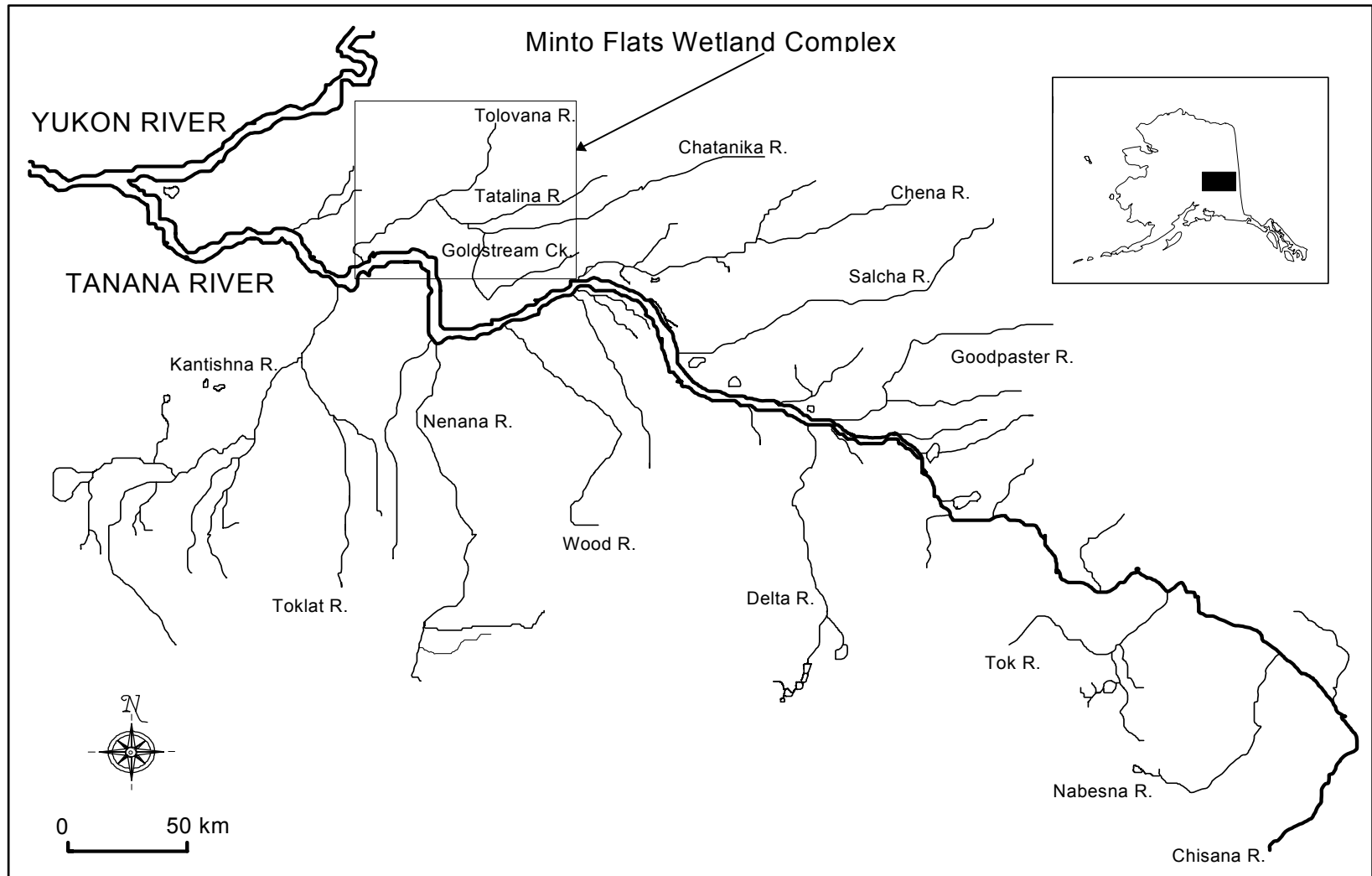


Figure 1.-Tanana River drainage.

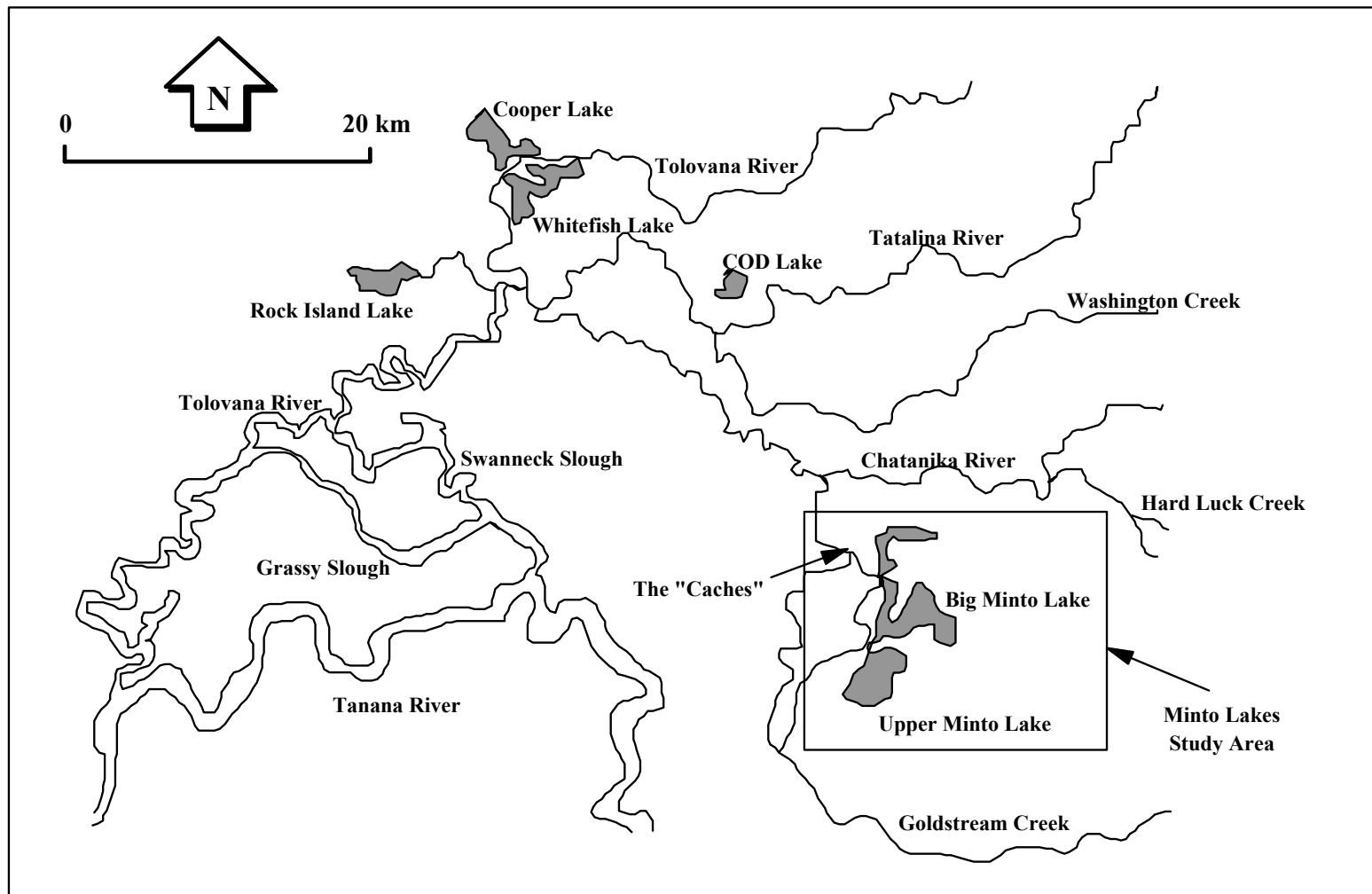


Figure 2.—Minto Flats wetland complex.

(Burkholder 1989, 1990, 1991; Hansen and Burkholder 1992). In addition to northern pike, least cisco *Coregonus sardinella*, humpback whitefish *C. pidschian*, broad whitefish *C. nasus*, sheefish *Stenodus leucichthys*, Arctic grayling *Thymallus arcticus*, burbot *Lota lota*, longnose suckers *Catostomus catostomus*, blackfish *Dallia pectoralis*, slimy sculpin *Cottus cognatus*, and lake chub *Couesinus plumbeus* are found in Minto Flats. Chinook salmon *Oncorhynchus tshawytscha* and chum salmon *O. keta* pass through parts of Minto Flats during migrations to and from spawning areas in the upper Chatanika River.

DESCRIPTION OF MINTO FLATS NORTHERN PIKE FISHERY

Minto Flats supported the largest sport fishery for northern pike in Alaska in 15 of the last 19 years (Mills 1979 - 1994; Howe et al. 1995; Howe et al. 1996). From 1981-1984 the average sport harvest in Minto Flats was 2,279 northern pike. However, in 1985, a new sport fishery developed on a concentration of over-wintering northern pike in the Chatanika River. This fishery resulted in an increase in the estimated sport harvest from 2,349 northern pike in 1984 to 4,665 fish in 1985, and 4,903 in 1986. Angler reports and limited creel survey sampling (Holmes and Burkholder 1988) indicated that a large proportion of the harvest from this new fishery was prespawning females.

Due to the increased winter harvest of large female northern pike, which concentrate in few locations and are easily caught, ADF&G closed the Minto Flats winter sport fishery for northern pike by emergency order in January 1987. In the spring of 1988 the Alaska Board of Fisheries restricted the sport fish season to June 1 through October 14 and reduced the bag limit to five northern pike a day only one of which can be over 30 inches TL (\approx 725 mm FL). Since the current regulations have been in effect, the estimated sport-fish harvest of northern pike in Minto Flats has fluctuated from 872 in 1989 to 8,438 in 1994 (Mills 1988 - 1994; Howe et al. 1995; Howe et al. 1996; Table 1). In addition, estimated angler days fluctuated from 699 in 1989 to 6,267 in 1994. This fluctuation in effort and harvest emphasizes the need for Minto Flats northern pike population assessment to help in maintaining this valuable fishery.

A subsistence fishery for northern pike occurs near the present village site (New Minto) and at historically used sites in the eastern portions of Minto Flats (Andrews 1988). Gill nets are used to catch northern pike throughout the open-water period and hook-and-line techniques are primarily used to capture fish through the ice. During the years from 1983 through 1988, estimated subsistence harvest ranged from a high of 3,003 northern pike in 1983 to 10 northern pike in 1986 (Russ Holder, ADF&G, memorandum dated January 13, 1989). The estimated 1994 harvest was 2,997 northern pike (Jim Marcotte, ADF&G memorandum dated February 9, 1995).

METHODS

The 1996 mark-recapture experiment was designed to estimate abundance and composition of northern pike germane to the Minto Lakes Study Area (Figure 2), which is the area of Minto Flats that attracts the majority of sport fish anglers, and during a time when the population is vulnerable to harvest.

Table 1.—Estimated angler days expended; number of northern pike harvested and caught; and catch per angler day and harvest per catch in Minto Flats, 1977-1995 summarized by all northern pike and northern pike > 725 mm FL^a.

Year	Angler Days	Number Harvested		Number Caught		Catch/Angler Day		Harvest/Catch	
		All	> 725 mm	All	> 725 mm	All	> 725 mm	All	> 725 mm
1977	3,886	3,615	-	-	-	-	-	-	-
1978	3,640	3,300	-	-	-	-	-	-	-
1979	2,709	3,209	-	-	-	-	-	-	-
1980	2,727	3,909	-	-	-	-	-	-	-
1981	2,045	2,009	-	-	-	-	-	-	-
1982	1,791	1,886	-	-	-	-	-	-	-
1983	1,281	1,825	-	-	-	-	-	-	-
1984	1,829	1,960	-	-	-	-	-	-	-
1985	2,011	3,902	-	-	-	-	-	-	-
1986	3,318	3,621	-	-	-	-	-	-	-
1987	1,539	1,161	-	-	-	-	-	-	-
1988	1,564	1,128	-	-	-	-	-	-	-
1989	699	872	-	-	-	-	-	-	-
1990	932	1,182	-	3,967	-	4.3	-	0.3	-
1991	1,532	1,754	297	4,907	535	3.2	0.3	0.4	0.5
1992	2,401	1,247	131	5,765	808	2.4	0.3	0.2	0.2
1993	3,911	2,076	170	19,536	5,238	5.0	1.3	0.1	0.0
1994	6,267	8,438	1,943	47,248	5,408	7.5	0.9	0.2	0.4
1995	6,260	3,126	594	21,823	2,463	3.5	0.4	0.1	0.2
Average	2,650	2,643	627	17,208	2,890	4.3	0.7	0.2	0.3

^a Daily fishing regulations within Minto Flats are such that only one northern pike over 30 inches TL (≈ 725 mm FL) may be retained or in possession.

SAMPLING TECHNIQUES

The study area was divided into 16 areas to examine movement, test for differences in catchability, and help insure uniform sampling effort (Figure 3). Generally, sampling took place between 0900 and 1700 hours each day. Each of four crews of two individuals sampled one area per day. Each crew deployed three gill nets at the beginning of the day and increased or decreased the number of gill nets to that which allowed fish to be sampled and released alive. Each area was sampled evenly and as uniformly as possible by moving the gill nets to new sites within the area throughout the day. All healthy northern pike were released immediately after data collection 50 to 100 m from the capture site.

All data from captured northern pike were recorded on ADF&G Tagging Length Mark-Sense Form, Version 1.0. A new form was used for each area. During the marking event, captured northern pike were measured and all these ≥ 300 mm FL were sampled. A minimum of two scales were taken from the preferred zone adjacent to but not on the lateral line above the pelvic fins as described by Williams (1955) and mounted on gummed scale cards. Corresponding mark-sense litho-code, date, and waterbody were recorded on the back of all gummed scale cards. Both the left and right side of the dorsal fin were examined for the presence of a Floy tag; and if present, the color and number of the tag recorded; or if not present, a new Floy FD-68 internal anchor tag inserted at the left base of the dorsal fin and the number recorded. The left pelvic fin of all newly tagged fish was slightly clipped as a secondary mark. Northern pike killed during the sampling procedure were not tagged but all other data were recorded and the fate (K) clearly noted in the blank space after the length on the mark-sense form. When possible, the sex of each northern pike was determined by the presence of milt or eggs.

During the recapture event, the same procedures were used with the addition that both the left and right pelvic fins were examined closely for recent clips, and the right pelvic fin, instead of the left, was slightly clipped to signify capture during the event. Tag loss (TL) was clearly noted in the blank space after the tag number on the mark-sense forms for northern pike without a Floy tag but with a recent tag wound or recent left pelvic fin clip. Recapture (RC) was clearly noted on the mark-sense form for known recaptures from the marking event. Northern pike were not sampled more than once during the recapture event.

Scales were impressed on 20 mil acetate sheets using a Carver press at 241,315 kPa (35,000 psi) heated to 150°C for 150 s from scales collected in the field on gummed cards. Ages were determined from impressions using a Micron 770 microfiche reader (32X) according to criteria established by Williams (1955), and Casselman (1967). Since scale collection was after the time of annulus formation, growth beyond the last annulus was considered plus growth.

All data files used to estimate parameters of the Minto Lakes northern pike population are listed in Appendix A1.

ESTIMATION OF ABUNDANCE

Abundance was estimated using a Petersen mark-recapture experiment (Seber 1982) based on the following assumptions:

- 1) the population was closed (no change in the number or composition of northern pike during the experiment);

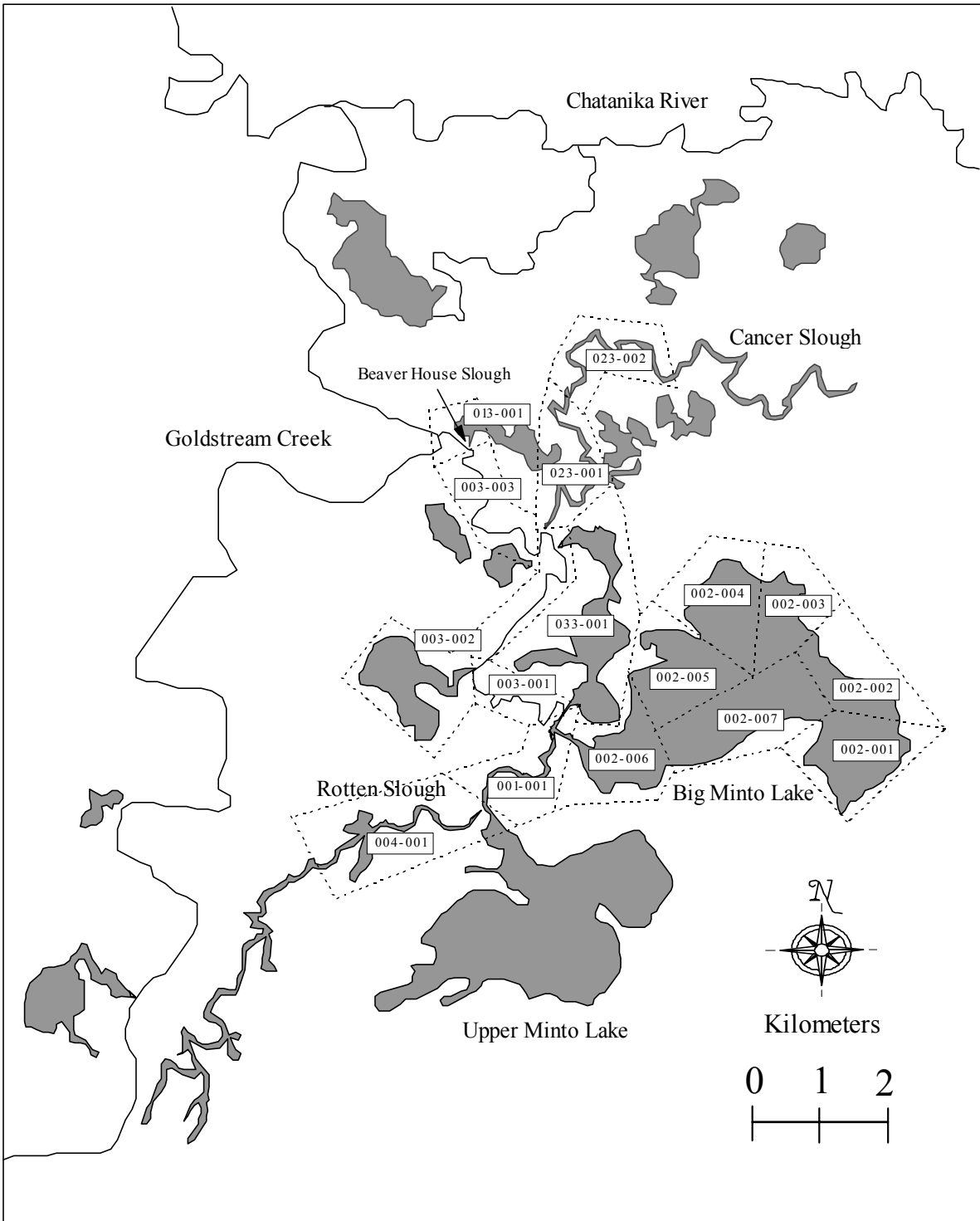


Figure 3.—Minto Lakes Study Area with designated sampling areas indicated with dashed lines.

- 2) all northern pike had the same probability of capture during the marking event or the same probability of capture during the recapture event or marked and unmarked northern pike mixed completely between events;
- 3) marking northern pike did not affect their subsequent probability of capture;
- 4) northern pike did not lose their mark between events; and,
- 5) all marked northern pike were reported when recovered.

The validity of assumption 1 was inferred from information gained from a two-year radio-telemetry study of northern pike movements within the study area. The least movement of radio-tagged fish occurred between the middle of June and the middle of July. During this time, none of the radio-tagged northern pike left the Minto Lakes Study Area (Roach *In prep*). Mortality and growth, which may contribute to the violation of assumption 1, were assumed negligible because of the short duration of the experiment (15 days from beginning to end). The validity of assumptions 2 and 3 was inferred by the systematic sampling design and from comparing movements of recaptured fish between events. Chi-square tests to compare catchability (probability of capture) among areas during the recapture event (the frequency of fish with marks to the frequency of fish without marks) were not performed because of the low number of recaptures. To determine bias in estimated abundance due to size selectivity, Kolmogorov-Smirnov two-sample tests were used to compare: 1) the cumulative length frequency distributions of recaptured northern pike with all northern pike captured during the marking event; and 2) the length frequency distributions of northern pike captured during the marking event with those captured in the recapture event. The validity of assumption 4 was insured by double marking (Floy tag and fin-clip) each northern pike. Tag loss was noted when a fish was recovered with the specific fin clip but without a Floy tag. The validity of assumption 5 was insured by a thorough examination of fins for fin-clips and the recording of fin clips and Floy tag numbers for all captured northern pike. Floy tag numbers used for this mark-recapture experiment were archived (Appendix B1).

Estimated abundance of northern pike was calculated from the number of northern pike marked, examined for marks, and recaptured. The Chapman estimator (Seber 1982) was used:

$$\hat{N} = \frac{(M+1)(C+1)}{R+1} - 1 \quad (1)$$

where: M = the number of northern pike marked and released alive during the marking event;
C = the number of northern pike examined for marks during the recapture event;
R = the number of northern pike recaptured during the recapture event; and,
 \hat{N} = estimated abundance of northern pike at the time of marking.

Variance of the abundance estimate (Seber 1982) was estimated as:

$$\hat{V}[\hat{N}] = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \quad (2)$$

ESTIMATION OF LENGTH AND AGE COMPOSITIONS

Length proportions of northern pike ≥ 400 mm FL were estimated for the Minto Lakes Study Area with procedures in Appendix C2. The proportion and variance estimators used were:

$$\hat{p}_k = \frac{x_k}{n}, \text{ and} \quad (3)$$

$$\hat{V}[\hat{p}_k] = \frac{\hat{p}_k(1 - \hat{p}_k)}{n - 1} \quad (4)$$

where: \hat{p}_k = the proportion of northern pike that were length k ;
 x_k = the number of northern pike sampled that were length k ; and,
 n = the number of northern pike sampled that were measured.

Age composition was estimated using the same equations for proportions and variances of proportions used to estimate length composition except ages were substituted for lengths. Length and age compositions data were archived (Appendices B2, B3).

Accuracy of age determination from scales of Minto Lakes northern pike captured during the 1996 mark-recapture experiment was tested indirectly. Error in assigning the correct incremental age for each fish was calculated as:

$$\text{ERROR} = \text{AGE}_{t+\Delta} - \text{AGE}_t - \Delta t \quad (7)$$

where: $\text{AGE}_{t+\Delta}$ = age assigned when fish was recaptured;
 AGE_t = age assigned at earlier capture; and,
 Δt = number of years elapsed from capture to recapture.

Mean error was calculated as the sum of all the errors divided by the number of fish recaptured.

A random subsample of 100 scales was read twice to determine the average percent error (APE of Beamish and Fournier 1981) of the scale reader:

$$\text{APE} = \frac{\sum_{i=1}^S \left[\frac{\sum_{j=1}^R \frac{|x_{ij} - \bar{x}_i|}{\bar{x}_i}}{R} \right]}{S} \cdot 100 \quad (8)$$

where: x_{ij} = age determined from the j^{th} reading of the i^{th} scale;
 \bar{x}_i = average age determined from the i^{th} scale;
 R = total number of readings; and,

S = total number of scales in the sample.

APE provides a means to evaluate the reproducibility of ages within a year, but should not be considered independent of age (Laine et al. 1991).

RESULTS

Of the 904 unique northern pike handled during the mark-recapture experiment, 332 were tagged and released alive during the marking event of which seven were subsequently recaptured, and 565 were captured during the recapture event. None were < 400 mm FL. During the experiment water temperature varied from 17° to 23° C. During the experiment 27 northern pike (< 3% of fish handled) were inadvertently killed, there was no observed tag loss, and 25 northern pike with Floy tags from prior mark-recapture experiments (< 3% of unique northern pike handled) were identified.

Estimated abundance of northern pike within Minto Lakes was germane to fish ≥ 400 mm FL during middle to late June 1996. The recapture rate (fish recaptured divided by fish examined for marks in the recapture event; R/C) was 0.01. Comparison of areas where northern pike were marked with areas where the fish were recaptured indicated no movement between areas. There was not a significant difference between the length distributions of northern pike marked and northern pike recaptured ($D = 0.38$; $P = 0.27$; Figure 4), however, due to the low number of recaptures, the power of this test was low. The necessity of stratification by length or area as outlined in Appendices C1 and C2 could not be determined satisfactorily. By default, abundance was estimated using the unstratified Chapman estimator based on the hypergeometric probability distribution. Estimated abundance of northern pike ≥ 400 mm FL within Minto Lakes was 23,850 fish (SE = 7,799; CV = 33%). The 95% profile likelihood bounds were 14,677 and 47,701 northern pike ≥ 400 mm FL.

There was a significant difference between the length distributions of northern pike marked and northern pike examined for marks during the recapture event ($D = 0.14$; $P < 0.01$; Figure 4). This, along with the inconclusive difference between length distributions of northern pike marked and northern pike recaptured, suggests that there was size selectivity during either the first event only, the second event only, or both events. This uncertainty can not be reconciled because of the low number of recaptures. Therefore, both events were combined to estimate length composition. Fork lengths measured from 899 northern pike ≥ 400 mm FL from Minto Lakes ranged from 400 mm to 1,002 mm (mean = 596 mm; SE = 3 mm; Figure 5).

Age was determined for 838 northern pike (≥ 400 mm FL) sampled during the Minto Lakes mark-recapture experiment--307 from the marking event and 531 from the recapture event. Ages were determined for 18 northern pike for which ages had been determined in previous years. The mean error in assigning the proper incremental ages in 1996 from the scales of 18 northern pike, which ages were determined in previous years was -0.72 years ($Z = 0.77$; $P = 0.44$); and the estimated average percent error of the scale reader in reproducing the same age twice in 1996 was 2.8% (Figure 6). Of Minto Lakes northern pike ≥ 400 mm FL, an estimated 51% (SE = 2%) were age-5 (Figure 7).

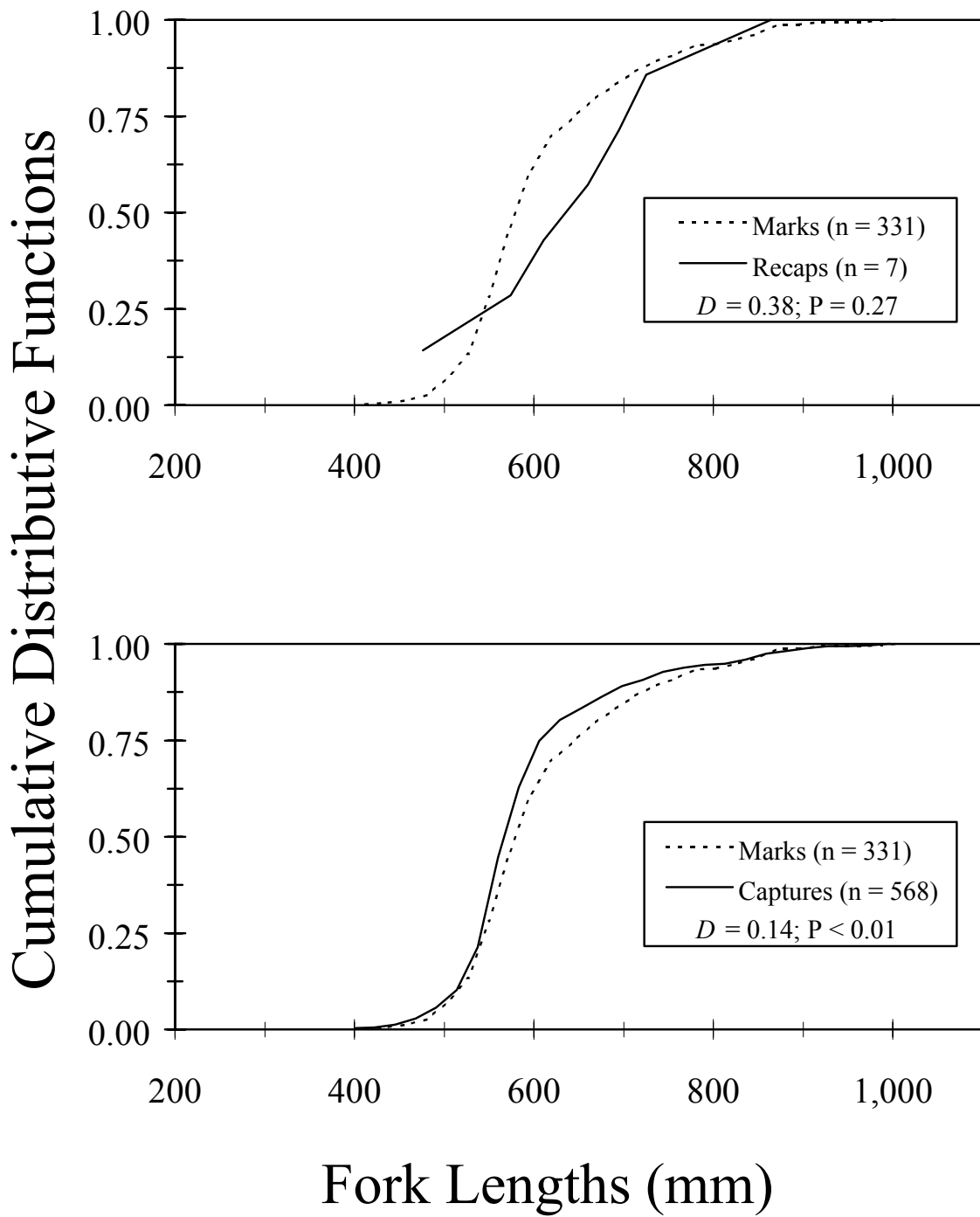


Figure 4.—Cumulative distribution functions of fork lengths of northern pike marked versus recaptured and marked versus captured in Minto Lakes.

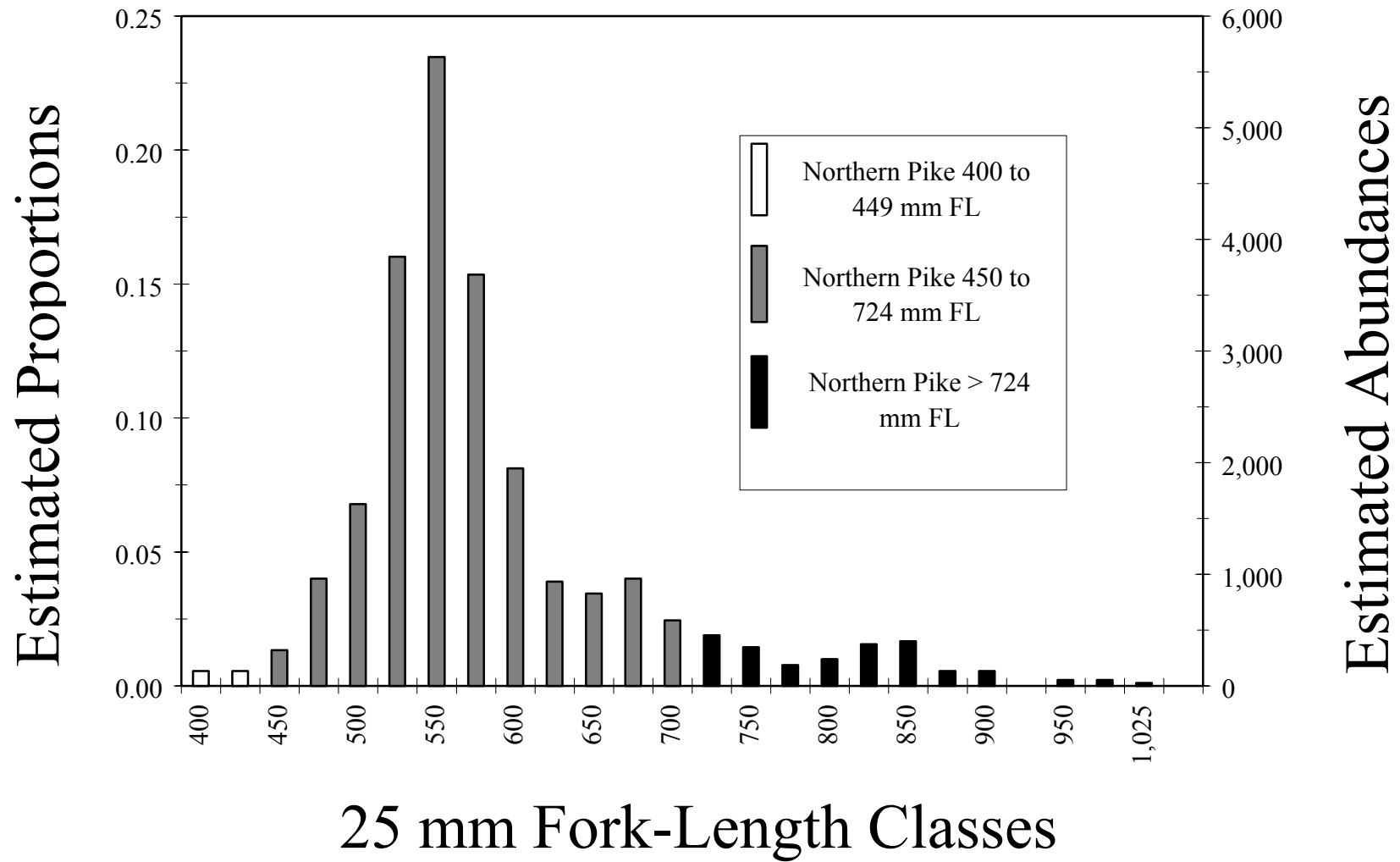


Figure 5.-Estimated proportions and abundances of northern pike ≥ 400 mm FL by 25-mm length classes within Minto Lakes during middle to late June 1996.

Of the 904 unique northern pike sampled, ages were not determined for 66 (scales were not taken or lost from 12 fish, not readable because of regeneration from 40 fish, and not readable because of poor acetate impression from 14 fish).

DISCUSSION

The methods of the 1996 Minto Lakes northern pike mark-recapture experiment were altered from previous years. The hiatus between the marking event and the recapture event was reduced by a magnitude of months, sampling took place in June instead of early May or September, and the study area was uniformly sampled instead of sampling only a limited number of locations. The hiatus was reduced to eliminate the need to adjust estimates of abundance because of growth recruitment between the events and reduce the opportunity for fish to leave or enter the study area. According to radio-telemetry data northern pike movement into and out of the Minto Lakes Study Area during June has been negligible in past years compared to the spring and fall. All northern pike recovered with marks in 1996 were recovered in the same area in which they were marked. Sampling took place in June to help ensure movement did not compromise the experiment. Systematic sampling was needed to compensate for this lack of movement during this time compared to spring and fall.

Low catch rates were a nagging problem in 1996. Northern pike were dispersed more than anticipated because water level was higher than normal, making sampling more difficult. In addition, the number of gill nets used and the duration of the soaks were reduced to keep handling mortality at $< 5\%$ of the fish sampled, which further reduced the numbers of fish sampled. Even though northern pike abundance in the Minto Lakes Study Area was estimated with only seven recaptures, diagnostic tests for equal catchability by length and area were not performed satisfactorily. Given the 1996 estimate of abundance, approximately 1,000 northern pike will need to be sampled in both marking and recapture events in the future to ensure a sufficient number of recaptures, and to examine bias from unequal catchability by length or area. Even in years of high water, however, catch rates and numbers of northern pike sampled may be improved by increasing the duration of the experiment, using hoop traps in addition to gill nets, and sampling during the cooler hours of the day which will allow the use of more gill nets per crew and longer soaks.

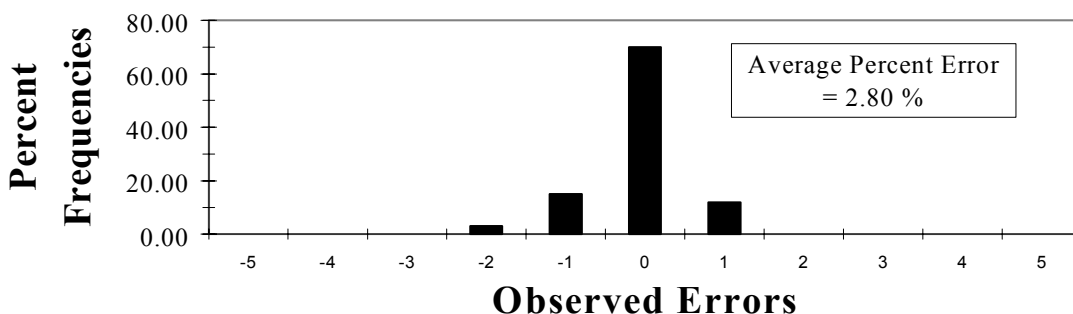


Figure 6.-Percent frequencies for observed errors in reproducing the same age twice from a Minto Lakes northern pike scale in 1996.

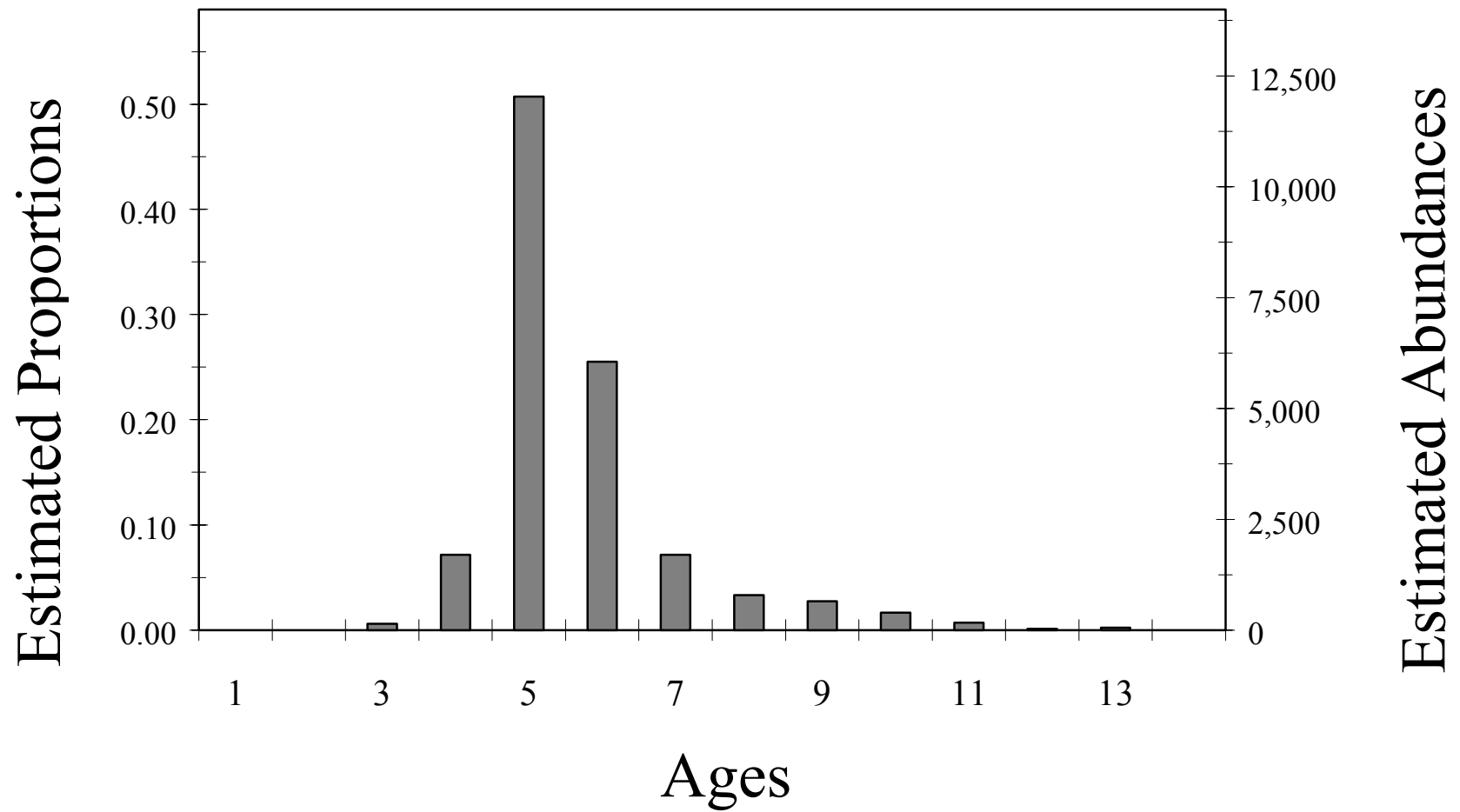


Figure 7.-Estimated proportions and abundances of northern pike ≥ 400 mm FL by ages within Minto Lakes during middle to late June 1996.

Table 2.— Estimated and average of abundances and standard errors of Minto Lakes northern pike ≥ 525 mm FL by years.

Years	Estimated Abundances	Estimated Standard Errors
1987	11,257	3,075
1988	13,233	3,143
1989	-	-
1990	27,418	6,800
1991	17,633	5,480
1992	-	-
1993	-	-
1994	-	-
1995	-	-
1996	20,695	6,765
Average	18,047	5,053

Given that the abundance of Minto Lakes northern pike ≥ 525 mm FL in 1996 was above the historical average but within the range of previous estimates of abundance (Table 2), at minimum the current sport fishing regulations should remain in effect. Hansen and Burkholder (1992) previously reported abundance estimates for Minto Lakes northern pike ≥ 525 mm FL for four years from 1987 to 1991; comparable abundance in 1996 was an estimated 20,695. These regulations limit the harvest of large northern pike (< 30 inches) to one per angler per day, and close the fishery during the winter and the time of spawning when these fish are congregated and vulnerable to over fishing. To more fully assess this northern pike population, the 1997 mark-recapture experiment should be designed to obtain a more precise estimate of abundance. Since a portion of the subsistence harvest occurs during the winter when the potential for over harvest is high, the subsistence harvest should be monitored closely with attention given to any increase in current levels of activity. The two previous estimates of subsistence harvest were both approximately 3,000 northern pike, which appears acceptable and should be used as a guide to recognize an increased harvest in this fishery.

ACKNOWLEDGMENTS

The author appreciates the help and comments from those who reviewed and edited this report as well as its operational plan, Peggy Merritt as research coordinator, Mike Wallendorf for biometric review, and Sara Case for the preparations necessary for publication. Thanks is also given to Fred Andersen and Peggy Merritt for supervisory support and encouragement. Additionally, a special thanks go to those who helped collect the data: Kirsten Bagne, Nancy Klemm, Margo Kramer, John Main, Brendan Scanlan, Corey Schwanke, and Lisa Stuby. The U. S. Fish and Wildlife Service provided partial funding for this study through the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under project F-10-12, Job 3-2(c).

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APPENDIX A

Data File Listing

Appendix A1.-Data files used to estimate parameters of the Minto Lakes northern pike populations, 1996.

Data file ^a	Description
U014ALA6.DTA	Population and marking data for Minto Lakes northern pike captured during the marking event, June 13 through June 16, 1996.
U014ALB6.DTA	Population and recapture data for Minto Lakes northern pike captured during the recapture event, June 17 through June 20 and June 24 through June 27, 1996.

^a Data files were archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.

APPENDIX B

Historical Data Summaries

Appendix B1.-Floy tag numbers used for Minto Flats northern pike mark-recapture experiments by year and color, 1987-1996.

Year	Tag Color			
	Green	White	Blue	Gray
1987		27,000-27,999 32,500-32,999 45,000-45,408 58,000-58,220		
1988	89,000-89,045	45,500-45,547 49,000-49,822 56,000-57,999 58,221-58,999		
1989	5,000-5,432 7,000-7,344			
1990			60,000-62,764 75,000-75,238	
1991			77,000-78,492 79,000-79,991	
1992-1993	-	-	-	-
1994				15,000-17,059 17,450-17,784
1995				9,719-9,735 53,700-53,749
1996			41,000-41,989	

Appendix B2.-Sample sizes, estimated abundances, and standard errors by length category for Minto Lakes northern pike, 1996.

Length	n	N	SE
400-424	5	133	43
425-449	5	133	43
450-474	12	318	104
475-499	36	955	312
500-524	61	1,618	529
525-549	144	3,820	1,249
550-574	211	5,598	1,831
575-599	138	3,661	1,197
600-624	73	1,937	633
625-649	35	929	304
650-674	31	822	269
675-699	36	955	312
700-724	22	584	191
725-749	17	451	147
750-774	13	345	113
775-799	7	186	61
800-824	9	239	78
825-849	14	371	121
850-874	15	398	130
875-899	5	133	43
900-924	5	133	43
925-949	0	0	0
950-974	2	53	17
975-999	2	53	17
>1,000	1	27	9
Totals	899	23,850	7.799

Appendix B3.-Sample sizes, estimated abundances, and standard errors by age for Minto Lakes northern pike, 1996.

Age	n	N	SE
1	-	-	-
2	-	-	-
3	5	142	47
4	60	1,708	558
5	425	12,096	3,955
6	214	6,090	1,992
7	60	1,708	558
8	28	797	261
9	23	655	214
10	14	398	130
11	6	171	56
12	1	28	9
13	2	57	19
14	-	-	-
Totals	838	23,850	7,799

APPENDIX C

Tests of Assumptions

Appendix C1.-Methodology to compensate for bias due to unequal catchability by section.

Case	Result of χ^2 Test ^a	Inspection of Fish Movement ^b	Inferred Cause
I	Fail to reject H_0	NO movement between sections	There is no differential capture probability by section (during the first event). Lack of movement among sections is evidence to exclude mixing between events as a reason for equal K/C ratios across sections.
II	Fail to reject H_0	MOVEMENT between sections	There is no differential capture probability by section of marked fish completely mixed with unmarked fish across sections.
III	Reject H_0	NO movement between sections	There is differential capture probability by section (during the first event) and marked and unmarked fish did not mix across sections (between events).
IV	Reject H_0	MOVEMENT between sections	There is differential capture probability by section (during the first event) and marked and unmarked fish did not mix completely among sections (between events).

^a The chi-squared test compares the frequency of marked fish recaptured during the second event in each section with the frequency of unmarked fish examined in the second event in each section. H_0 for this test is: capture probability of marked fish in the second event is the same in all sections.

^b Inspection of fish movement is a visual comparison of the frequency of marked fish recaptured in the second event that moved from one section to another with the frequency of unmarked fish examined in the second event in each section.

^c Case I: Calculate one unstratified abundance estimate using the Chapman estimator (Seber 1982).

^d Case II: Calculate one unstratified abundance estimate using the Chapman estimator (Seber 1982).

^e Case III: Completely stratify the experiment by section, calculate abundance estimates for each using the Chapman estimator (Seber 1982), and sum abundance estimates.

^f Case IV: Completely stratify the experiment by section. Test H_0 : proportion of fish marked in the first event is the same in all sections. This test compares the frequency of fish recaptured with marks in the second event to the frequency of fish marked in the first event. If H_0 is not rejected, calculate abundance estimates for each using the Chapman estimator (Seber 1982) and sum estimates. If H_0 is rejected, calculate abundance with the partially stratified model of Darroch (1961).

Appendix C2.-Methodology to compensate for bias due to gear selectivity by means of statistical inference.

Case	Result of First K-S Test ^a	Result of second K-S test ^b	Inferred Cause
I	Fail to reject H_0	Fail to reject H_0	There is no size selectivity during either sampling event.
II	Fail to reject H_0	Reject H_0	There is no size selectivity during the second sampling event, but there is during the first sampling event.
III	Reject H_0	Fail to reject H_0	There is size-selectivity during both sampling events.
IV	Reject H_0	Reject H_0	There is size selectivity during the second sampling event, the status of size-selectivity during the first event is unknown.

^a The first K-S (Kolmogorov-Smirnov) test is on the lengths of fish marked during the first event versus the lengths of fish recaptured during the second event. H_0 for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish recaptured during the second event.

^b The second K-S test is on the lengths of fish marked during the first event versus the lengths of fish captured during the second event. H_0 for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish sampled during the second event.

^c Case I: Calculate one unstratified abundance estimate, and pool lengths and ages from both sampling events for size and age composition estimates.

^d Case II: Calculate one unstratified abundance estimate, and only use lengths and ages from the second sampling event to estimate size and age composition.

^e Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Pool lengths and ages from both sampling events and adjust composition estimates for differential capture probabilities.

^f Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Also calculate a single abundance estimate without stratification.

Case IVa: If stratified and unstratified estimates are dissimilar, discard unstratified estimate and use lengths and ages from second event and adjust these estimates for differential capture probabilities.

Case IVb: If stratified and unstratified estimates are similar, discard estimate with largest variance. Use lengths and ages from first sampling event to directly estimate size and age compositions.